Wilts & Berks Canal
Melksham River Route Study
Appendix E: Hydrology and Hydraulics

CONTENTS

1. INTRODUCTION

1.1 The River Avon bisects the town of Melksham, Wiltshire some 15km east of Bath, refer Figure E1. The River Avon is a main river with a catchment of 660 km^2 upstream of Melksham.

1.2 As a part of the restoration of the Wilts & Berks Canal it is proposed to use the River Avon as a navigation channel to allow the canal to pass through the centre of Melksham. This will require changes to the hydraulics of the river in order to maintain sufficient draught for canal boats. This study outlines the hydrological and hydraulic analysis that has been carried out in order to ensure the following:

- The river hydraulics are such that the channel is navigable during the agreed design flow events
- The changes to the channel hydraulics do not have a detrimental effect on flood risk at any location
- The impact on tributaries, discharge and abstraction points and any structures adjacent to the channel is assessed

2. HYDROLOGY

2.1 The River Avon at this point drains a catchment of approximately 660km² above Melksham. The catchment is mainly agricultural although there are significant urban communities at Chippenham and Malmesbury.

2.2 The flood hydrology for the current study is based on the pre feasibility report prepared by Lewin, Fryer and Partners (LFP), now Black & Veatch Ltd, for the Environment Agency (EA) Bristol Avon Local Flood Defence Committee in January 2003. This report looked at a variety of flood risk scenarios along the reach of the River Avon through Melksham. As part of this pre feasibility report, the flood flows were assessed using the Flood Estimation Handbook (FEH) procedures.

2.3 Low flow data has been derived from the Melksham Gauging station record (the station is now closed), and may underestimate flows appreciably. The flow data for various return periods that have been used for the current design are summarised below in Table 2.1.

Table 2.1 River Avon flow estimates.

Flow condition	Flow m^3/s
Q95 (flow exceeded 95% of the time)	1
Mean flow (exceeded 50% of the time)	7
Q10 (flow exceeded 10% of the time)	15
1 in 2 years	79
1 in 5 years	104
1 in 10 years	121
1 in 25 years	145
1 in 50 years	165
1 in 100 years	188
1 in 200 years	212

3. HYDRAULIC MODEL

3.1 A HEC-RAS version 2.2 model of the River Avon through Melksham was constructed by LFP for the January 2003 pre feasibility report. This model was based on cross sections from a further study carried out in 1995 (Section 105 Report Pilot Study, Catchment 30,

Lower Bristol Avon, 1995, Parkman) and the flows given in Section 2 of this Report. The model has a bed slope of 1 in 3046 (based on longitudinal section of river) and adopted Manning's 'n' values of 0.1 and 0.045 for the floodplain and channel respectively. The Manning's values were derived from standard references and verified by calibration.

3.2 For the 2003 report the model was calibrated using event data from the 1960 flood, spot gaugings undertaken by the Agency between 1954 and 1996, and photographic evidence from an event in April 2000, which approximates to the Mean Annual Flood.

3.3 For the current study the model has been updated to HEC-RAS version 3.1.3, which is the most recent version. Additional cross sections from the 1995 report have been used to extend the model a further 2000m upstream.

3.4 Based on the observations from the site visit, six additional cross sections were inserted into the model to allow better representation of the local topography between Town Bridge and Challymead Bridge. These sections were derived by interpolation from surveyed cross sections for the channel.

3.5 A site visit has confirmed the need to accurately model friction and expansion related energy losses during extreme flows. This was achieved through reassessment of the roughness coefficients and consideration of the energy losses associated with the expansion of the flood plain downstream of Town Bridge.

3.6 The changes that we have made to the model do not impact significantly on the water levels. A comparison of the calculated existing water levels at selected locations during the 1 in 100 year and the 1 in 2 year flow events is shown in Table 3.1 below.

Table 3.1 Comparison of calculated 1 in 100 year and 1 in 2 year existing water levels at selected locations from pre-feasibility and 2006 revised HEC-RAS models

Location	1 in 2 year water levels		1 in 100 year water levels	
	Pre feasibility	Revised Pre feasibility	Pre feasibility	Revised Pre feasibility
u/s of Melksham Gate	33.62	33.60	34.89	34.86
u/s of Town Bridge	33.49	33.46	34.61	34.57
u/s of Challymead Bridge	33.36	33.33	34.28	34.23

4. CANAL OPERATION

4.1 Ensuring that the river is suitable for navigation is a balance between the need to provide sufficient air draught beneath each of the bridges and the need for sufficient bed draught to the river bed. In order to assess the available air and bed draught, the following canal dimensional requirements have been assumed:

- Min air draught required = 2.3m over 2m width
- Min towpath headroom required = 2.0m over 2.0m width
- Min bed draught required = 1.5m over 10m wide navigation channel + 20% additional bed draught (300mm) to allow for long term siltation on the river

4.2 Inevitably during the most extreme high flow events the channel will not be navigable. It is accepted (in common with many navigations) that it will be necessary to close the canal over the winter period. For the purposes of the current study it has been assumed that the channel will not be navigable when flow rates rises above that which is exceed 10% of the time (Q10, i.e. approximately 37 days per year).

4.3 Although day moorings will be provided through the town, no permanent moorings are proposed. During high flows boats will not be permitted on the river. Holding bays will be

provided above the locks at the canal river junctions, out of the floodplain, to provide shelter for boats that cannot pass through the town.

4.4 Liaison may be necessary with the Environment Agency Flood Incident Management in order to obtain flood warnings to allow boats to leave the navigation prior to a significant flood event. However, most of the period when navigation would not be possible due to high flows would be during the winter, when the navigation would be closed.

4.5 In order to allow navigation of the river up to the Q10 event it is proposed that the existing Melksham Gate weir and sluice will be removed and a new weir constructed approximately 800m downstream. The HEC-RAS model of the River Avon in Melksham, which is described in Section 3 above, was modified to determine the weir that would be required in order to allow navigation through Melksham.

4.6 Design of the weir is discussed further in Section 5 below. Using this structure it will be possible to comfortably meet the design requirements listed in 4.1 above.

5. WEIR DESIGN

5.1 An outline plan and section of the proposed new weir are included as Figures E2 and E3. The plan and section are schematic only and are provided primarily to highlight the main critical components of the design. Further detailed work, particularly on architectural form, health and safety requirements, operational aspects etc are required. In order to provide sufficient bed draught during low flows whilst maintaining adequate head draught during the Q10 event it will be necessary to adjust water levels using a control structure. It is proposed that two 2m wide, 2m high tilting weir structures will be installed adjacent to the fixed weir for fine water level control. The adjustable weirs will also aid ongoing operation and maintenance on the river not associated with navigation.

5.2 The sluices would be automated (controlled by water levels recorded upstream of the sluice). However, the sluices are not required in relation to managing floods. This is a major difference to the design of the present Melksham Sluice where the existing gate is an integral part of the flood defence infrastructure. Flood risk is discussed in Section 6.

5.3 The new sluices would be designed to ‘fail safe’ i.e. it will not be possible to accidentally lower the sluices to lose navigation depth and impact on present abstractions (particularly the abstraction utilised by Cooper Avon). The ‘overshot’ design (where water flows over the sluices rather than under them) is inherently safer with respect to maintaining upstream levels (unlike the present Melksham Sluice which is undershot and has failed open in the past).

5.4 A fish pass will be required adjacent to the weir and Figures E2 and E3 show a Larinier type structure. A long, low gradient fishpass could also be installed if preferred, and the most appropriate structure will be agreed with the Environment Agency during detailed design. In addition, an eel/elver pass could be installed on the tilting weir gates if required. Discussions with the Environment Agency confirm that this combined facility will be a significant improvement on the existing fish pass at Melksham Sluice, which is poor by present standards.

5.5 Removal of the existing Melksham Gate will open up a further 800m of the Avon through Melksham for boat use. The plans of the proposed weir show a canoe pass to further increase the recreational potential of the river. Inclusion of this structure is subject to due consideration of health and safety requirements at the weir. At present a boom has been shown on the plan of the weir, but does not cross the canoe pass. This layout will also be reviewed to ensure it meets appropriate standards of health and safety. Further discussions would be undertaken with relevant local groups to maximise the potential of the weir for canoeing and ‘white water’, providing a safe design can be accommodated.

5.6 Consideration has been given to utilising a different shaped design, such as a horseshoe shape. However although visually attractive, there are major safety risks associated with

the complex hydraulic conditions related to such weirs, and this would have to be considered very carefully.

5.7 During large flood events the weir would be submerged and there would be significant floodplain flow on either side. Therefore the structure is likely to be bypassed and would be subject to erosion at either end if not designed correctly. At this stage it has been assumed that bank training and revetment works will be required to prevent scour at the structure. An existing borehole close to the structure indicates that ground conditions are 300mm of silty soil over clay to a depth of 3.0m. No further details are known at this stage and additional site investigation will be required prior to detailed design of the structure.

6. FLOOD RISK

6.1 A critical element of the development of a navigation in Melksham relates to the impact on flood risk. The existing flood risk in Melksham and the options to address this risk are summarised in the 2003 Pre Feasibility Study undertaken by LFP.

6.2 There have been major floods in Melksham in 1925, 1932, 1960 and 1968. The 1968 flood was the most severe of these events and was assessed to have a return period of about 1 in 100 years. Works were subsequently undertaken in the 1960s and 1970s to reduce flood risk to the town.

6.3 The modelling carried out as part of the 2003 pre feasibility study confirmed that property flooding would be expected in the 1 in 50 year event. In the 1 in 100 year event approximately 41 properties would be flooded. The study concluded that a comprehensive new flood defence scheme for Melksham could not be justified, because of the relatively low flood risk, and the relatively modest economic benefits that would be derived from it.

6.4 As there is an existing flood risk in the town it is essential that the proposed changes to allow navigation through Melksham do not increase this risk.

6.5 The HEC-RAS model described in Section 3 above was used to determine the impact of the navigation works on flood levels. For the purposes of modelling the flood risk it was assumed that the tilting weirs were in the shut position, representing a worst case scenario. The model confirms that there is no increase in flood level for any location for any return period between the 1 in 2 year and 1 in 100 year event. In fact, water levels are generally reduced by a small amount. A comparison of the flood levels for each of these events at selected locations through Melksham is shown in Table 6.1 below.

Table 6.1 Comparison of calculated 1 in 100 year and 1 in 2 year water levels at selected locations prior to and following proposed works

Location	1 in 2 year water levels			1 in 100 year water levels		
	Before	After	Diff.	Before	After	Diff.
u/s of Murray Bridge	34.13	34.09	-0.05	35.32	35.20	-0.12
u/s of Melksham Gate	33.60	33.50	-0.10	34.86	34.63	-0.23
u/s of Town Bridge	33.46	33.43	-0.03	34.57	34.54	-0.03
u/s of Challymead Bridge	33.31	33.29	-0.02	34.18	34.14	-0.04
u/s of proposed weir	33.30	33.27	-0.03	34.12	34.12	0.00

6.6 This analysis suggests that the existing Melksham sluice and weir is a small restriction to flow, which would be removed with the proposals. Most of the assets at risk from flooding are downstream of the existing weir and sluice. However the analysis suggests that there will be some flood risk benefit to the site currently occupied by Cooper Tires.

6.7 The modelling assumes that the proposed tilting weirs are in the closed position during the flood, representing a worst case scenario. Further flood risk benefits could be achieved by opening the tilting weirs in an event. The impact of operating the tilting weirs during a flood would be particularly beneficial during the smaller return period flood events.

6.8 The existing Melksham Sluice structure includes a 14.4m wide broad crested weir and a 9m wide sluice gate. The existing sluice gate is a fundamental flood risk management asset and if it were to fail closed then flood risks would be increased. Modelling has shown that flood levels in some parts of Melksham would be raised by between 300mm and 600mm depending on flood event, causing flooding. As part of the new proposal this risk would be removed by the removal of the existing structure. The new weir structure is not dependant on any sluice operation during flood events as the two small sluices are only required for low flow control and were assumed closed during all hydraulic modelling.

6.9 The hydraulic modelling that has been carried out leads to the conclusion that the installation of a new weir downstream of the town, when carried out in conjunction with the removal of the existing sluice and weir would be a benefit to the town. The reduction in flood risk will also extend to areas adjacent to South Brook and Clackers Brook, the two River Avon tributaries through Melksham.

6.10 In addition to the large return period flooding that is discussed above, the possibility of increasing low return period day to day nuisance flooding has also been considered. This is thought to be a particular problem on South Brook upstream of the confluence. Construction of the new weir will not impact on water levels during the 1 in 2 year event and above but would raise water levels on the Avon by 1.7m in the Q95 event and 0.45m in the Q10 event.

6.11 If left unchecked this increased water level at the confluence with South Brook during low flow events may exacerbate existing day to day nuisance flooding. This flooding could be prevented by appropriate operation of the two tilting weirs and it may also be possible to carry out enhancement works to alleviate the existing flood issues. Depending on the extent of the current problem potential mitigation measures could include diversion of South Brook downstream of the new weir, and this has been allowed for in the estimates. The environmental impacts associated with these works are discussed in the Environmental Assessment.

6.12 As discussed in section 4 above boats will not be permitted on the river during flows in excess of the Q10 event. It is therefore very unlikely that a boat would remain on the river prior to a flood. However, liaison may be necessary with Environment Agency Flood Incident Management in order to obtain flood warnings to ensure all boats leave the navigation prior to a significant flood event.

6.13 As discussed above, the new weir will not serve any flood risk management purpose and is purely for fine water level control to allow navigation of the river from the low flow up to the Q10 event. It is proposed that the structure will be designed with a remote operation facility and so it may be possible to lower the tilting weirs during a flood to provide some flood risk management benefit, if this is considered worthwhile. The hydraulic modelling has shown that flood levels with the tilting weirs shut are lower than the existing case and there is therefore no need to operate the structure during a flood event. Additionally there are risks to existing abstractions if water levels were to fall to low (e.g. if the sluices were not adjusted appropriately after a flood event). At this stage non-operation of the sluices during flood events is preferred.

7. ASSESSMENT OF POTENTIAL IMPACTS DUE TO CHANGES IN WATER LEVEL

7.1 Section 6 above demonstrates that water levels will not be raised during flood flow events. However, during the much smaller design flow events the water level will be significantly higher than at present downstream of the existing gate and significantly lower than at present upstream of this structure. It is acknowledged that this could have an impact at various sites through Melksham.

7.2 Environmental and geomorphological impacts are discussed in separate studies and are therefore outside of the scope of this Appendix. Figure E4 illustrates the sites that may be affected in other ways by the change in water level, and the modelled changes in water level that would occur. Table 7.1 below summarises the potential impacts of these changes and the proposed mitigation, if required, at each of the sites. Possible enhancements are also listed where appropriate.

7.3 It has been assumed that the change in the water levels will take place over an adequate time period to ensure that adverse geotechnical conditions (ie 'rapid drawdown') are avoided. In addition, upstream enhancement works will reduce the upstream impacts and prevent destabilisation of banks. These upstream works are discussed further in the Environmental Assessment.

Table 7.1: Sites potentially impacted by changes in water level and proposed mitigation

Site	Change in water level		Potential Impact[1]	Proposed mitigation
	Q95[2]	Q10[2]		
Wessex Water (WW) Outfall	+1.69	+0.45	Outfall already submerged, additional surcharging caused at Melksham STW	Liaison with WW and provision of new outfall downstream of proposed weir
South Brook	+1.69	+0.45	1 in 2 year and above flood risk unaffected Existing small event flooding could be exacerbated	Operation of tilting weirs will mitigate impact on small event flood risk, enhancement works could be carried out to mitigate existing problem. If necessary South Brook could be diverted downstream of the new weir.
Challymead Bridge	+1.69	+0.45	Additional loading on bridge piers and embankments	Impact likely to be negligible, further analysis to be carried out at detailed design stage
Town Bridge	+1.67	+0.43	Additional loading on bridge piers and embankments	Impact likely to be negligible, further analysis to be carried out at detailed design stage
Clackers Brook	+1.67	+0.43	Flood risk unaffected. Existing stability issues on masonry river channel walls upstream of confluence (behind scout hut) will not be impacted by increased water level.	Not required – enhancement potential in the form of stability works on masonry walls upstream of confluence (eg ground anchors).
Cooper Tires abstraction	-1.00	-0.95	Current abstraction point would be above water level.	Liaison with Cooper Tires and provision of new abstraction point at a lower level nb new weir would be fail safe overshot structure therefore existing risk of loss of abstraction due to failure of Melksham Gate will be removed
Melksham loop confluence	-0.92	-0.95	No impact	
Murray Walk Bridge	-0.92	-0.95	Additional hydrostatic loading on bridge piers and embankments leading to stability problems	Impact likely to be negligible, further analysis to be carried out at detailed design stage
Melksham loop bifurcation	-0.92	-0.95	Existing feed is above water level – no impact	Enhancements could include permanent water feed from the canal.
River walls/embankments upstream of Melksham Gate	Between 0.00 and -1.00	Between 0.00 and -0.95	Reduced hydrostatic loading leading to stability problems	Impact likely to be negligible, further analysis to be carried out at detailed design stage
River walls /embankments downstream of Melksham Gate	Between 0.00 and -1.00	Between 0.00 and -0.95	Increased hydrostatic loading leading to stability problems	Impact likely to be negligible, further analysis to be carried out at detailed design stage

Notes:

1) Environmental and geomorphological impacts are covered in separate studies and are therefore outside of the scope of this report

2) Q95 = flow rate exceeded 95% of the time, Q10 = flow rate exceeded 10% of the time

7.4 It is known that failure of the existing undershot Melksham Gate in the open position has, in the past, led to a drop in water level on the River Avon, which has prevented abstraction at Cooper Tires. This in turn has led to closure of the plant until raised water levels can be re-established. Replacement of the existing structure with a fail safe overshot penning structure will prevent these drops in water level in the future, hence improving surety of water supply to Cooper Tires.

8. LEGAL ISSUES: OWNERSHIP AND OPERATION

8.1 The purpose of this report is to address the technical issues relating to the use of the River Avon as a navigation through Melksham. It is acknowledged that there are a number of outstanding legal issues that will need to be resolved before the canal is operational. These include:

- Agreement with the Environment Agency and other interested parties regarding ownership and operational responsibility for the new weir
- Agreement with the Environment Agency and other interested parties regarding maintenance of the navigable section of the River Avon
- Securing navigation rights on the River Avon
- Decision regarding navigation authority for the canal (assumed at this stage to be British Waterways)
- Operational restrictions to prevent river navigation during flood events (including liaison with EA Flood Incident Management to obtain appropriate flood warnings)

9. CONCLUSIONS

9.1 It is proposed to use the River Avon as a navigation route for the K&A canal through Melksham. In order to provide sufficient air and bed draught it will be necessary to construct a new weir 800m downstream of the existing Melksham sluice, the existing sluice will then be demolished. This study investigates the operational requirements of the canal, the impact of the works on the flood risk to Melksham and the impact of the change in water level that the works will cause.

9.2 Both flood flow data and low flow data has been taken from the pre feasibility report prepared by Lewin, Fryer and Partners (LFP), now Black & Veatch Ltd, for the Environment Agency (EA) Bristol Avon Local Flood Defence Committee in January 2003. An updated and revised version of the HEC-RAS steady state hydraulic model of the Rive Avon through Melksham from the pre feasibility study has also been used.

9.3 It has been assumed that the river should be navigable from low flows up to the Q10 event. Hydraulic modelling has confirmed that the proposed new weir will provide sufficient bed and air draught to allow river navigation within this range. Holding areas will be provided at both of the river canal junctions to provide shelter for boats that are unable to pass through the town due to lower or higher flows.

9.4 The proposed new control structure will be a 20m wide fixed weir with two 2m wide, 2m high overshot tilting weir gates is proposed. Additional infrastructure will be installed for fish passage, and potentially for canoeists. The weir is for fine water level control from the low flow up to the Q10 flows and does not serve any flood management purpose. Further architectural, health and safety, and operational design work is required. A different architectural and structure form is possible, but would need to perform the engineering tasks as discussed above.

9.5 The 2003 pre feasibility study confirmed that property flooding would be expected in Melksham during the 1 in 50 year event and for all more significant events. Hydraulic modelling has illustrated that removal of the existing sluice and weir and installation of a new weir downstream of the town would bring about a small decrease in the flood risk to

the town. This will be the case even if the new tilting weirs are in the shut position during a flood. The existing flood risk associated with failure of the Melksham Sluice in the closed position during a flood will also be eliminated. The reduction in flood risk will also extend to areas adjacent to South Brook and Clackers Brook, the two River Avon tributaries through Melksham.

9.6 The works will lead to an increase in the water level between 0.45m and 1.69m immediately upstream of the new weir and a decrease in the water level of approximately 1.0m immediately upstream of the location of the demolished existing sluice. This will lead to a number of impacts that will require mitigation and/or further investigation at the detailed design stage. Environmental and geomorphological impacts resulting from the change in water level are covered in separate studies. Water level control at the new weir will be via fail safe overshot tilting weirs. The existing risk of failure of Melksham Sluice in the open position resulting in a drop in water levels and inability for Cooper Tires to abstract from the river will therefore be removed.

9.7 The current study addresses the technical issues relating to the use of the River Avon as a navigation through Melksham. There are a number of legal issues that will need to be resolved before the scheme can become operational.